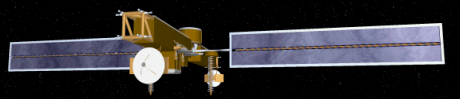


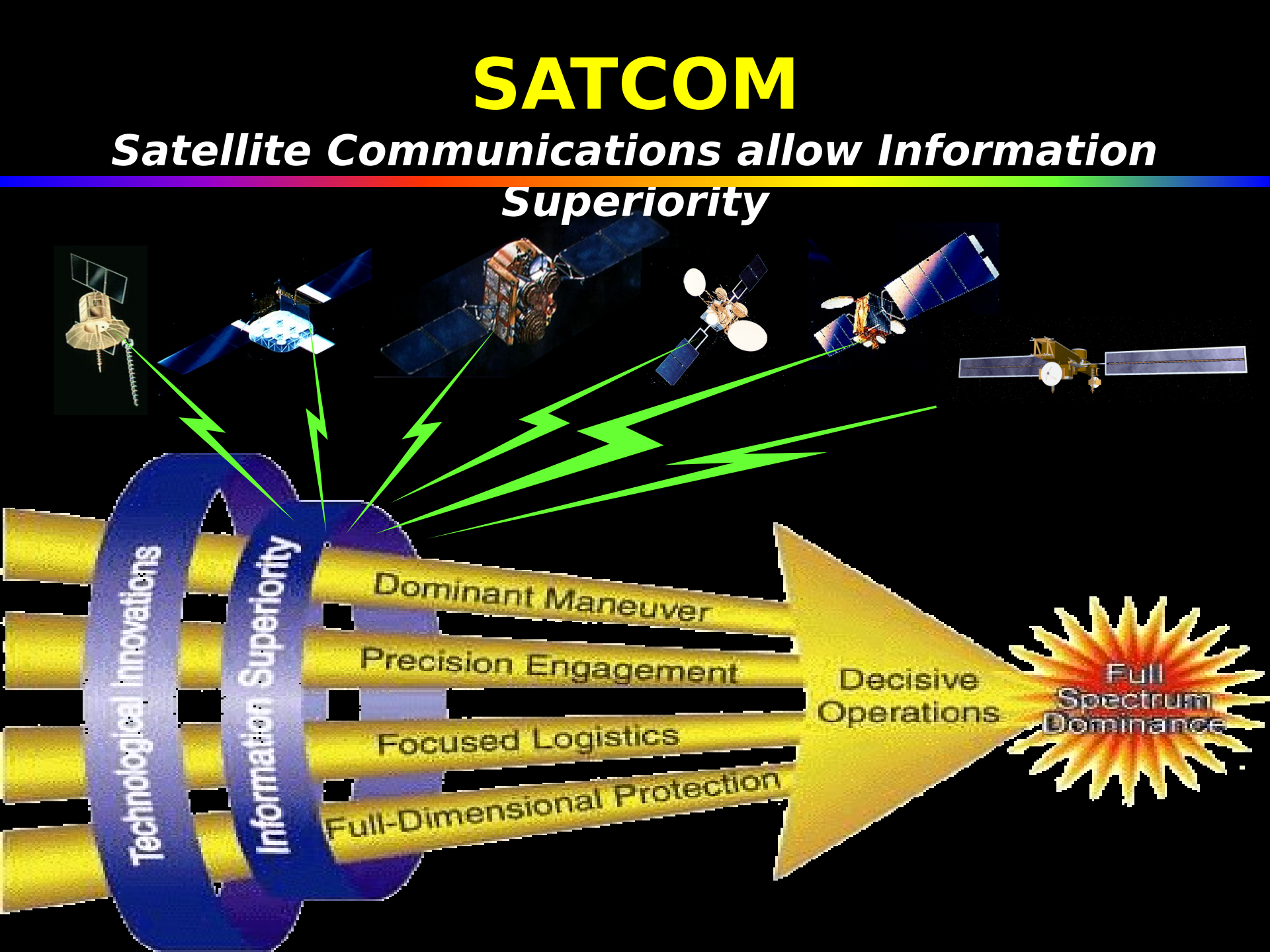
Satellite Communications (SATCOM)

Business of Space
5 Dec 2001

Space Operations Scho

SATCOM

Satellite Communications allow Information Superiority



Overview

- Basic Principles
- Military Satellite Communications
- Commercial Satellite Communications
- The Way Ahead

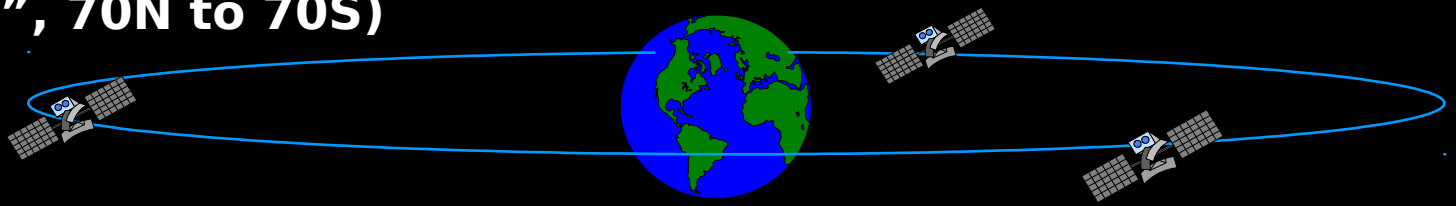
Overview

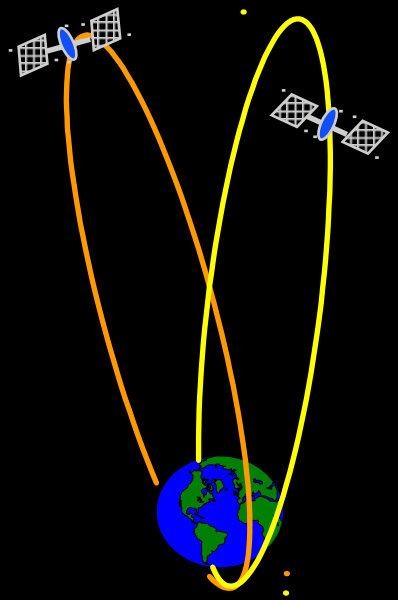
- **BASIC PRINCIPLES**
- **Military Satellite Communications**
- **Commercial Satellite Communications**
- **The Way Ahead**

Communication Satellite Orbits

Geosynchronous (GEO)

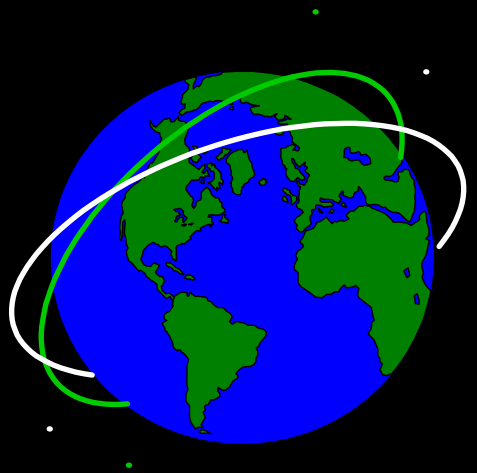
("Global", 70N to 70S)





Highly Elliptical (HEO)

lorthern or Southern Hemisphere)



Low Earth (LEO)

("Global")

Satellite Communications Link

Uplink

Downlink

Repeater or Processor

- Receive
- Translate
- Transmit

Transmitter

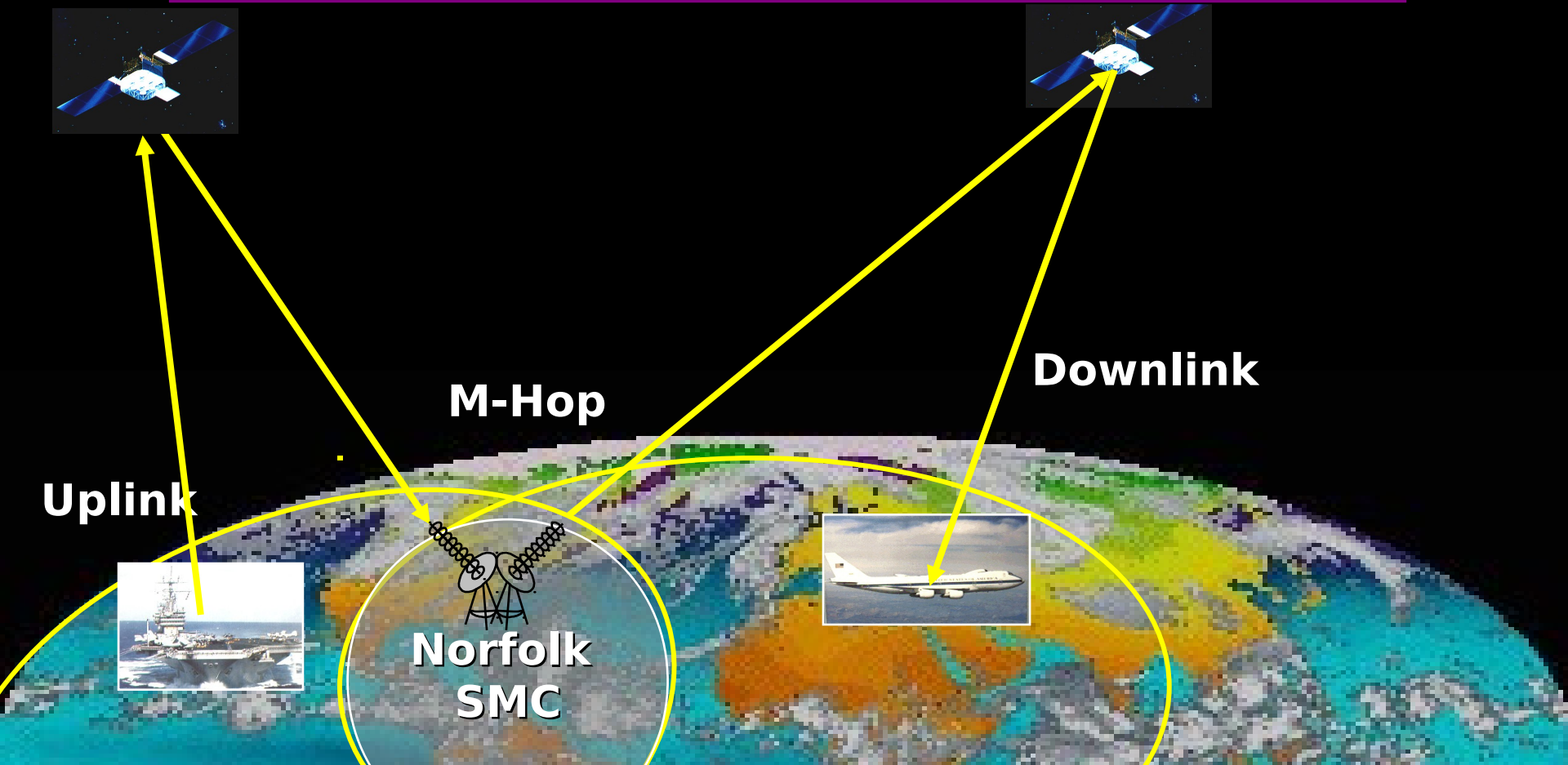
- Process
- Modulate
- Convert
- Amplify

Receiver

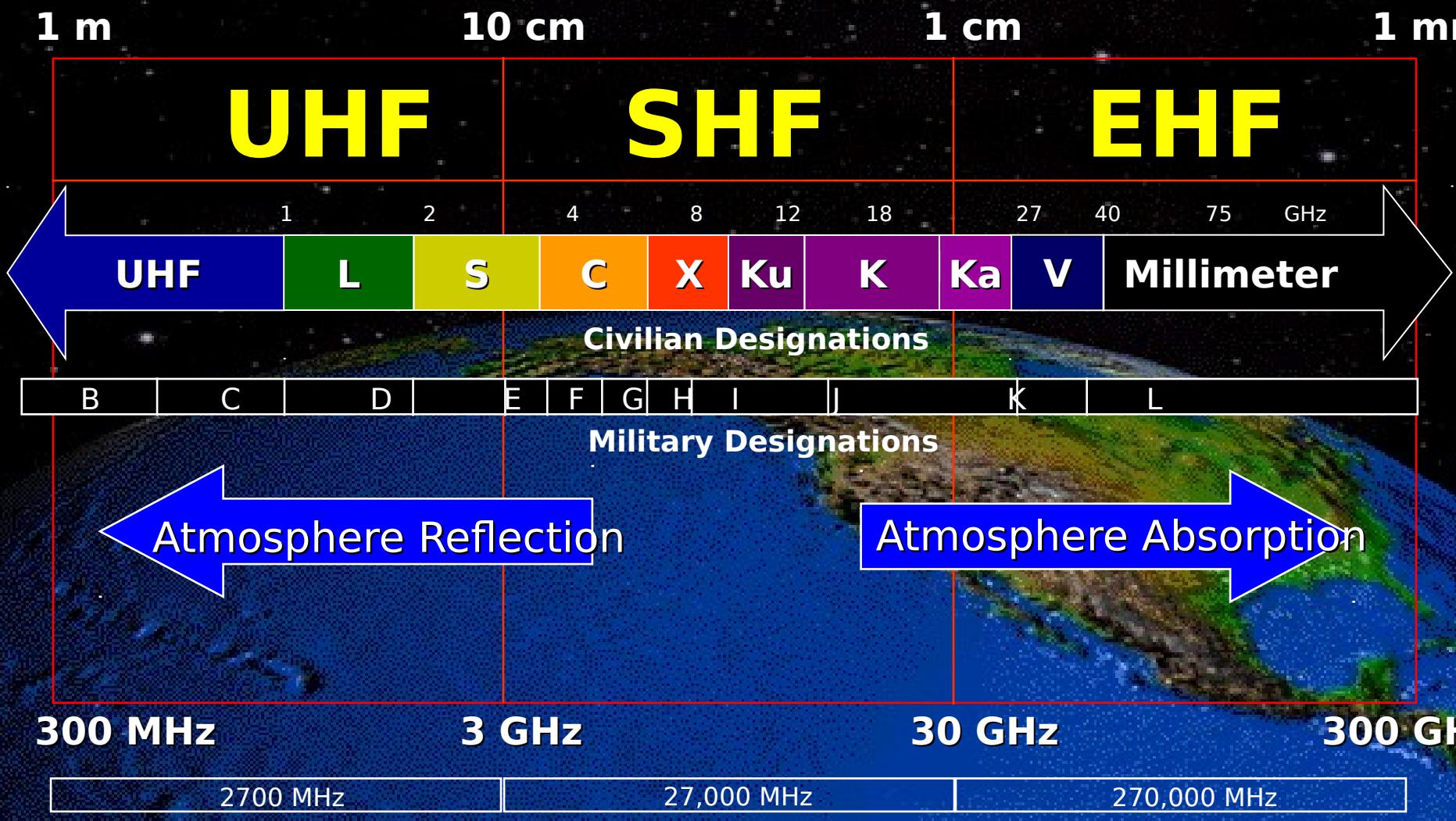
- Amplify
- Convert
- Demodulate
- Process

Bent Pipe (M-Hop)

M-Hops are used by almost all worldwide satellite communications systems, to include the AFSCN!



Space Frequencies



Space Frequencies

1 m | 10 cm | 1 cm | 1 mm

UHF	SHF	EHF
2,700 MHz	27,000 MHz	270,000 MHz
Approx 10,000 Phone Calls	Approx 100,000 Phone Calls	Approx 1,000,000 Phone Calls

Anti-jam

Footprint

1/3 of Earth | AOR | Theater

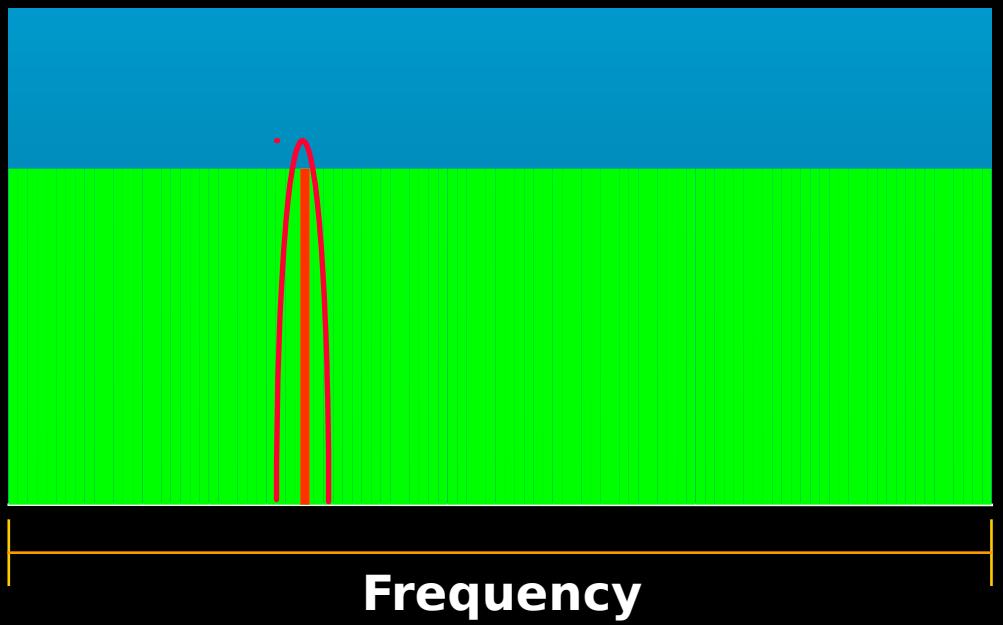
Nuclear Scintillation

Blocked 2-3 hours | Blocked 2-3 minutes | Blocked 2-3 seconds

300 MHz | 3 GHz | 30 GHz | 300 GHz

Anti-Jam/Frequency Hopping

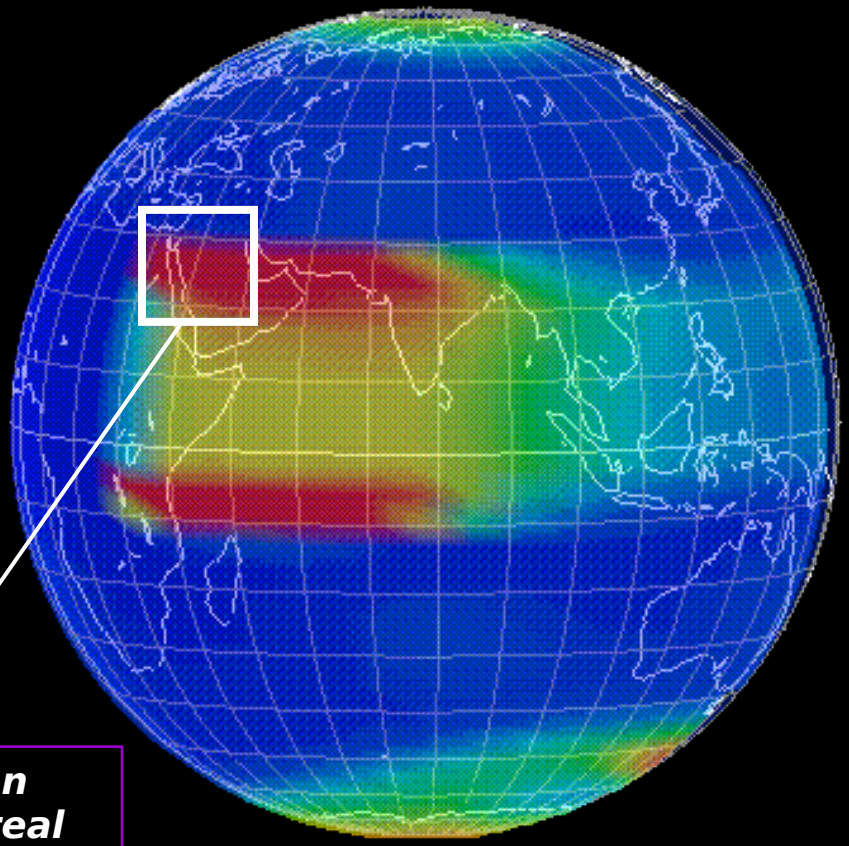
- Single frequency operation on a narrowband channel is easy to jam
- Frequency hopping allows you to hop off the jammed frequency to others
- The more you hop the more frequency you use up
- Speed and frequency separation depends on communications system
  - SINCGARS
  - HAVE QUICK
  - MILSTAR
- Requires precise timing



Ionospheric Scintillation Impacts

Scintillation due to the **Space/Solar Environment** impacts the Ionosphere and the downlink to the SATCOM Receiver

Primarily affects UHF SATCOM



Scintillation Leve

Severe

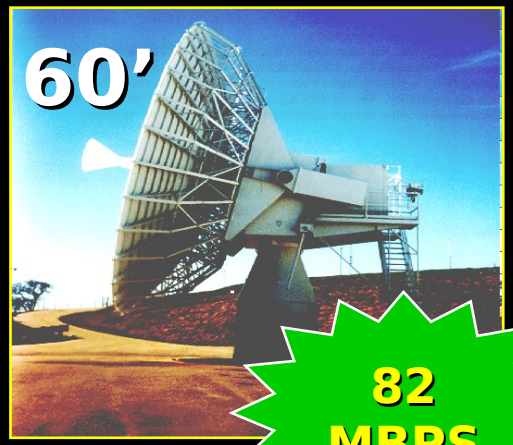
Moderate

None

Scintillation posed an unexpected but very real challenge during the Persian Gulf war.

Power Trade-Off

Transponder power and antenna size dictate dat



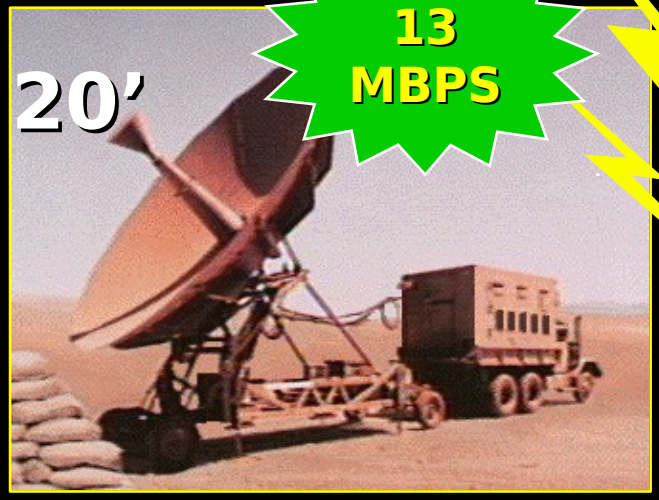
82 MBPS

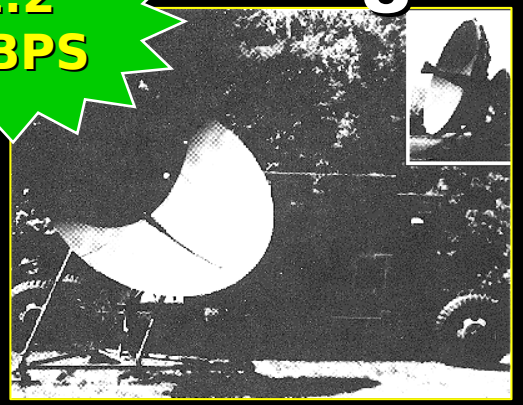
0.4 MBPS

1 MBPS

13 MBPS

1.2 MBPS



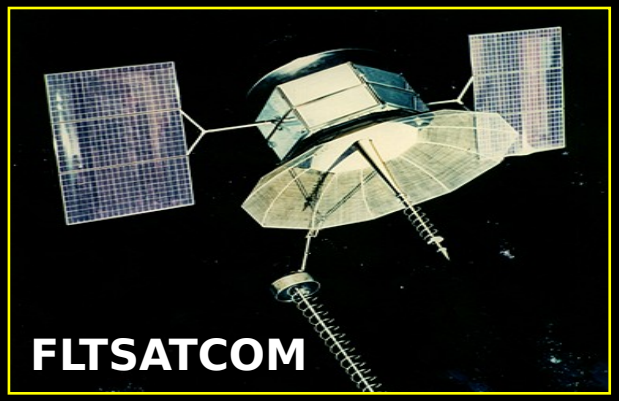


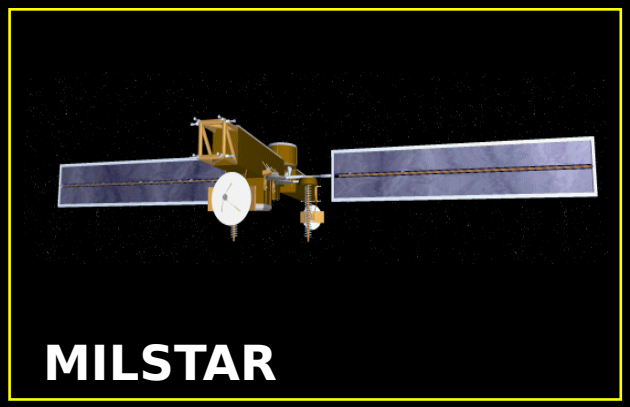
40 Watt transponder

Overview

- Basic Principles
- **MILITARY SATELLITE COMMUNICATIONS**
- Commercial Satellite Communications
- The Way Ahead

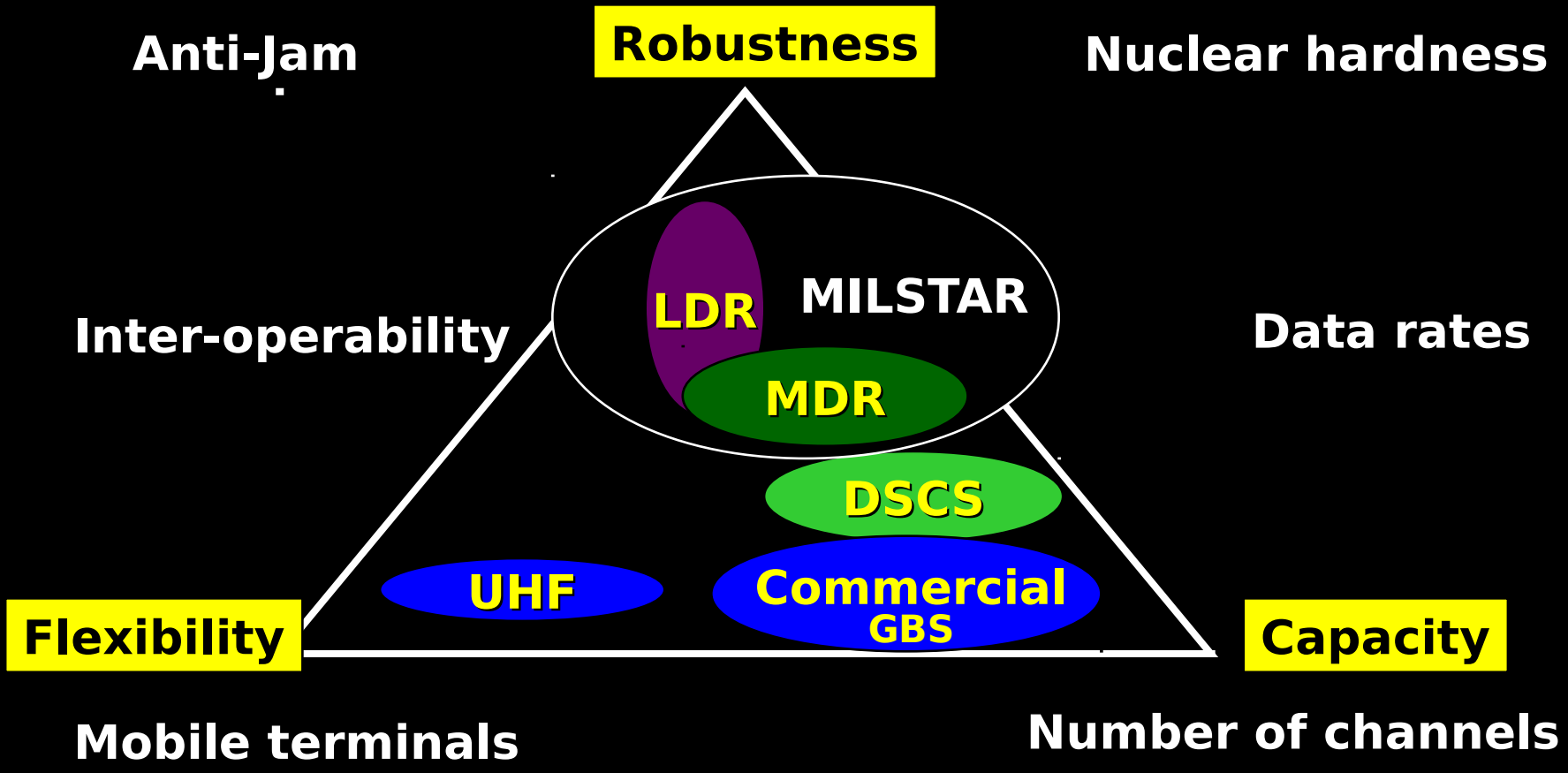
MILSATCOM Mission



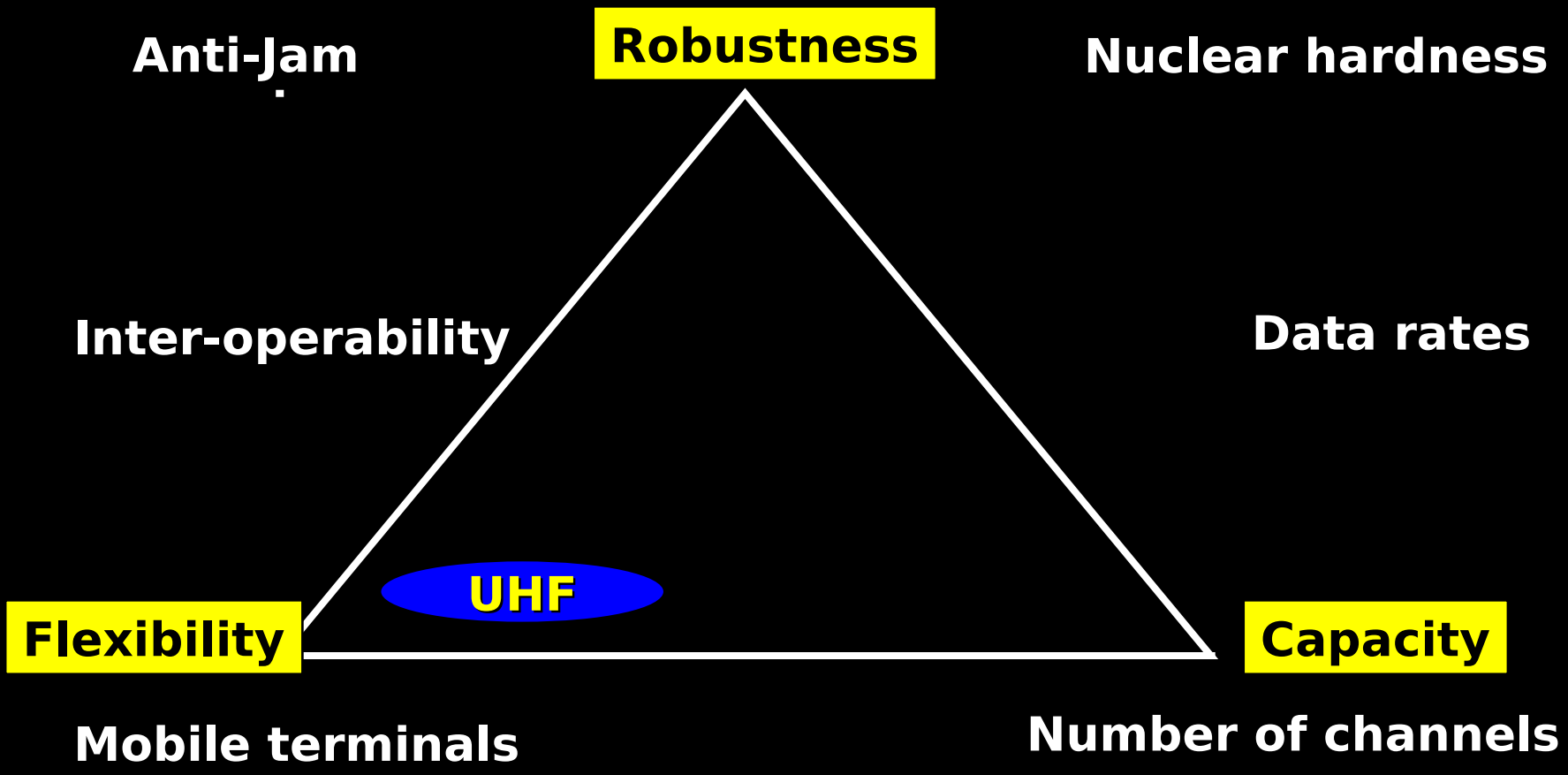


Provide timely access to information and dissemination of decisions to globally deployed military forces

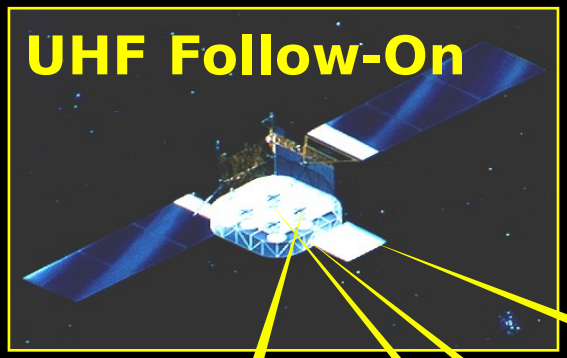
MILSATCOM Requirements



UHF MILSATCOM

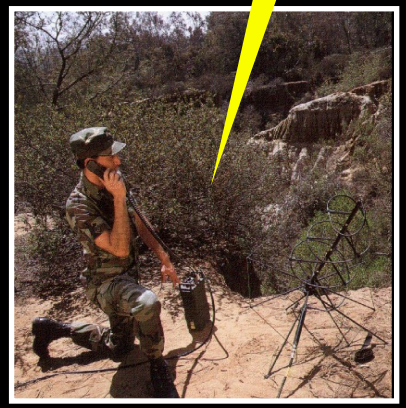


UHF Capabilities/Limitations



- All weather
- Penetrates jungle foliage
- Small antennas/terminals
- More easily jammed
- Small pipe/limited spectrum

30% of CINC's UHF requirements cannot be met



Army/SOF

C-17

Fleet Broadcast

UHF MILSATCOM Mission

Global, Tactical Communications for Naval Aircraft, Surface Ships, Submarines and Shore Stations

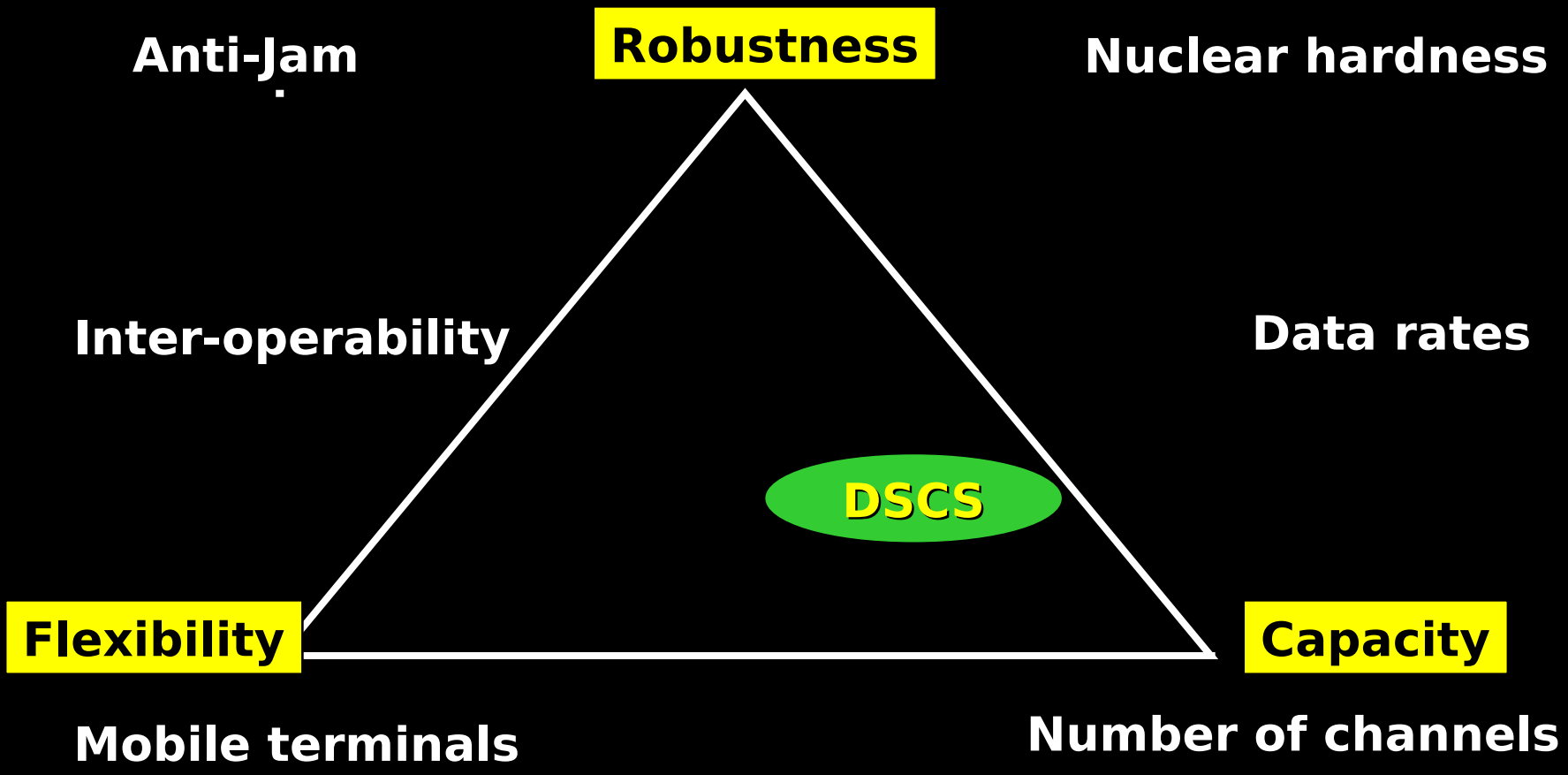
USN LAND, SEA, AIR FORCES

- Data Distribution
- Indications and Warning
- Fleet Broadcast
- Tactical Communications
- Tactical Intelligence Broadcast
- Tactical Missile Warning

AFSATCOM

- Emergency Action Messages (EAMs)
- Nuclear Force Command & Control

SHF MILSATCOM



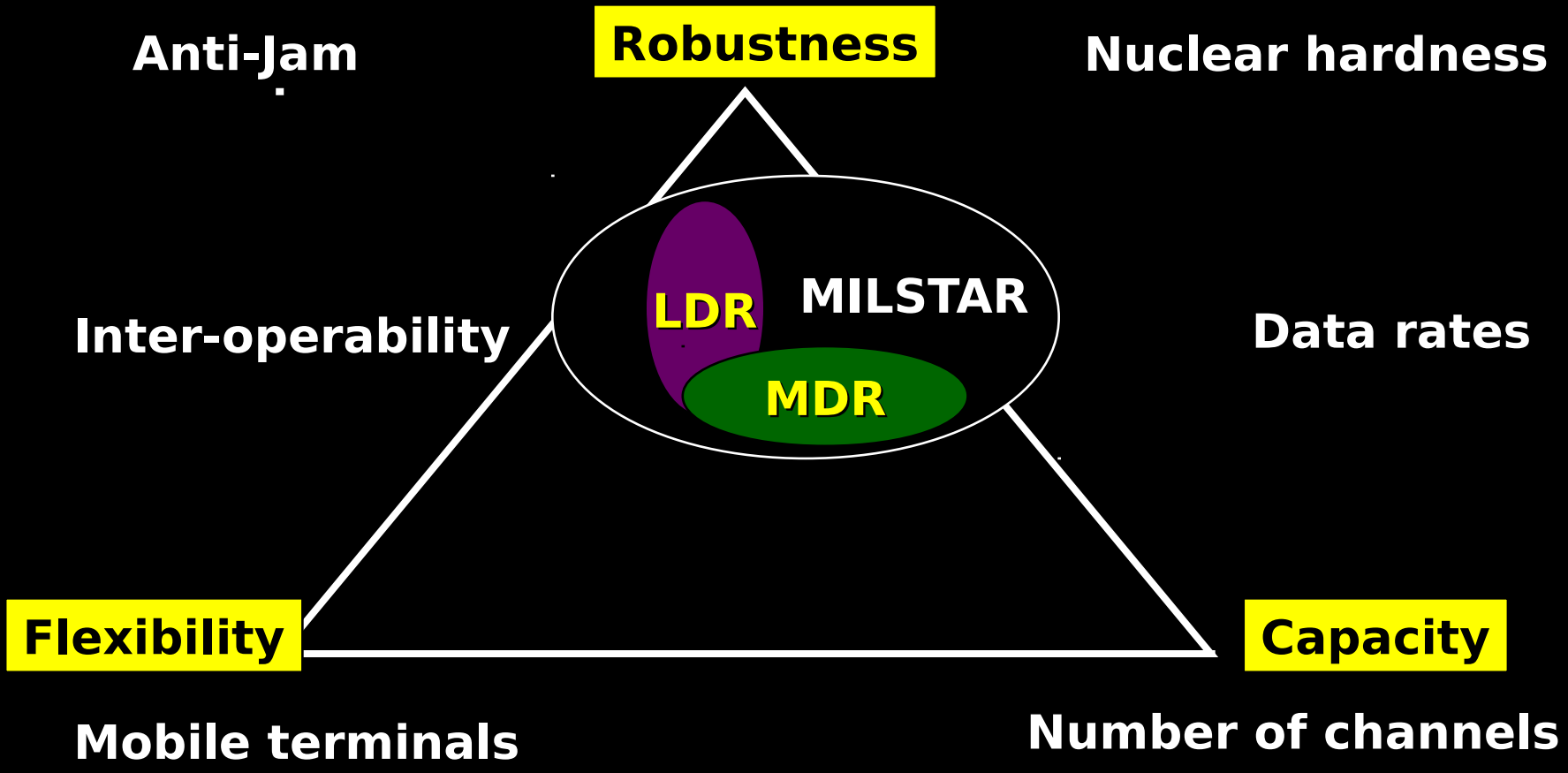
SHF SATCOM Systems
Defense Satellite Communications System

- Secure, Survivable Communications for the Global C2 System (GCCS)
- Carries the load for the Warfighter
- Residual satellites critical to supporting daily and wartime requirements
- Service Life Enhancement Program (SLEP) for last 4 built (2/4 launched)
  - Increased power
  - Increased communication capacity by up to 200 percent

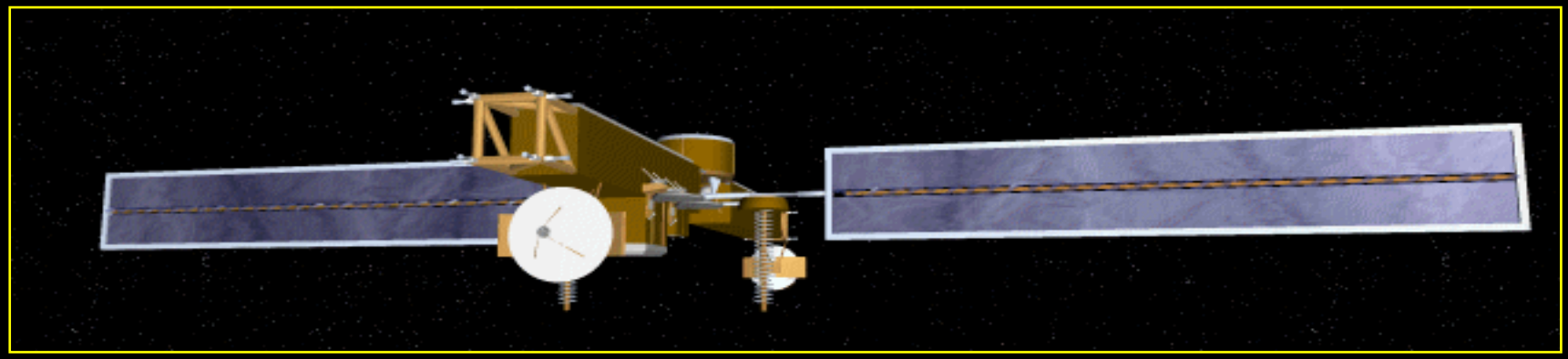
Defense Information System Network (DISN)

- Defense Switched Network (DSN)
- Defense Message System (DMS)
- SIPRNET/NIPRNET
- Intelink
- Defense Intelligence Infrastructure (DII)
- Defense Intelligence Network (DIN)
- Joint Worldwide Intel Comm System (JWICS)

EHF MILSATCOM



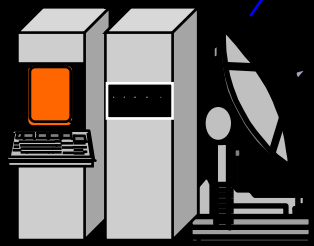
Milstar
(Priority/Precedence)

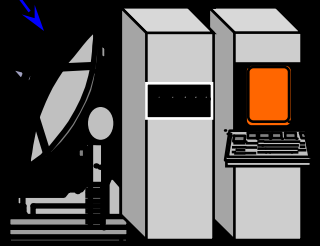


- Provide survivable, enduring, minimum essential communications for command & control of the warfighting forces of the united states
- CINCs are apportioned capacity, and CINCs direct implementation for their users
- Milstars 1-2, Low Data Rate 2.4 Kbps only
- Milstars 4-6, Additional Medium Data Rate (1.544 Mbps)

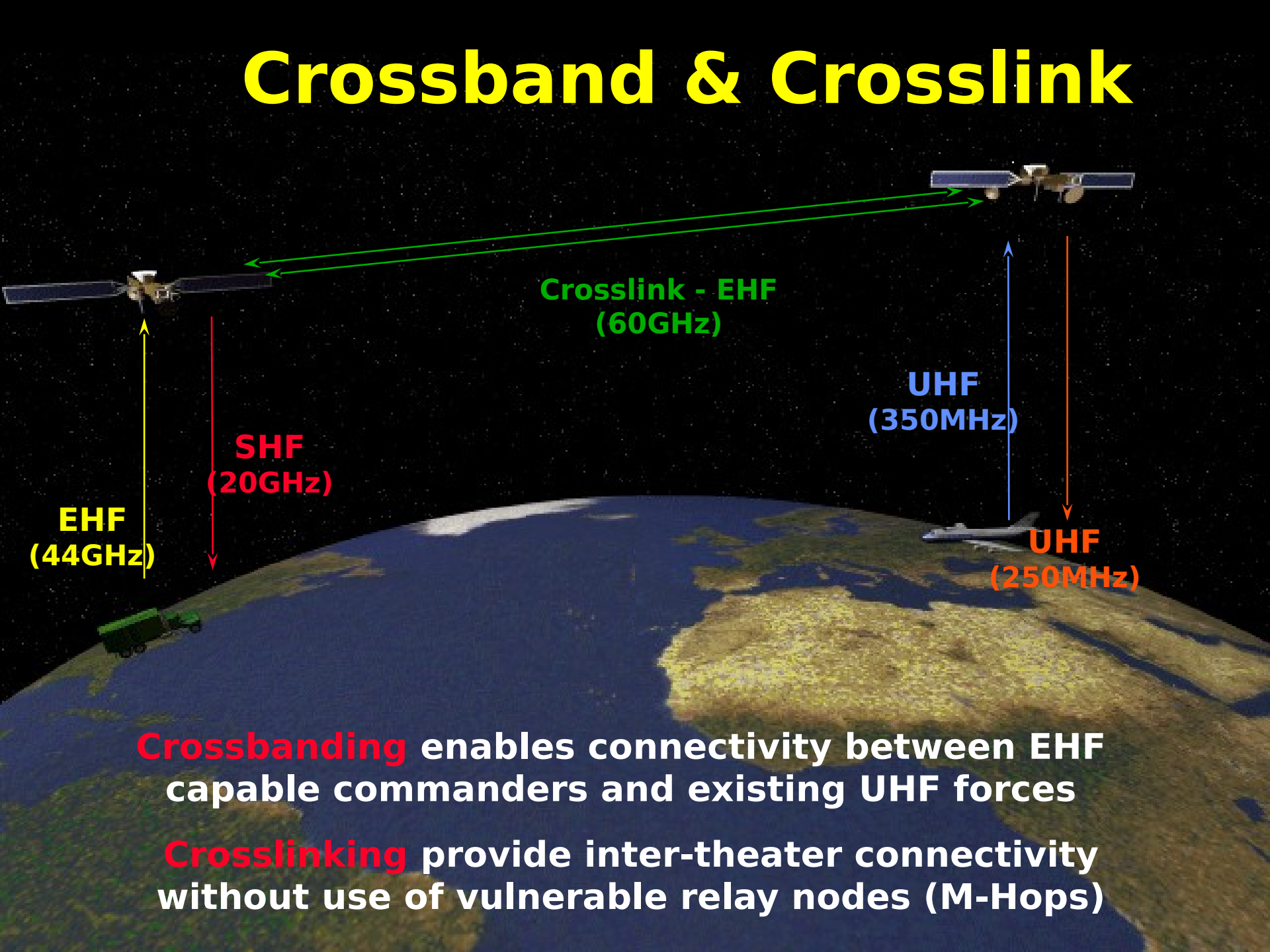
Milstar's Key Technologies

- On board signal processing
- On board routing
- On board resource control
- Cross banding
- Cross links





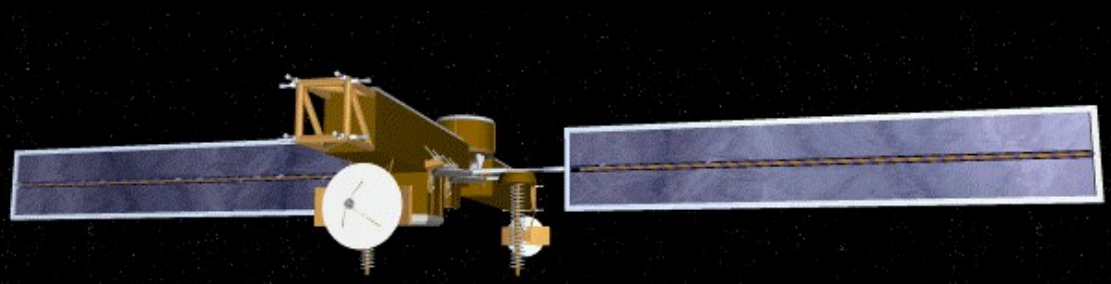
Crossband & Crosslink



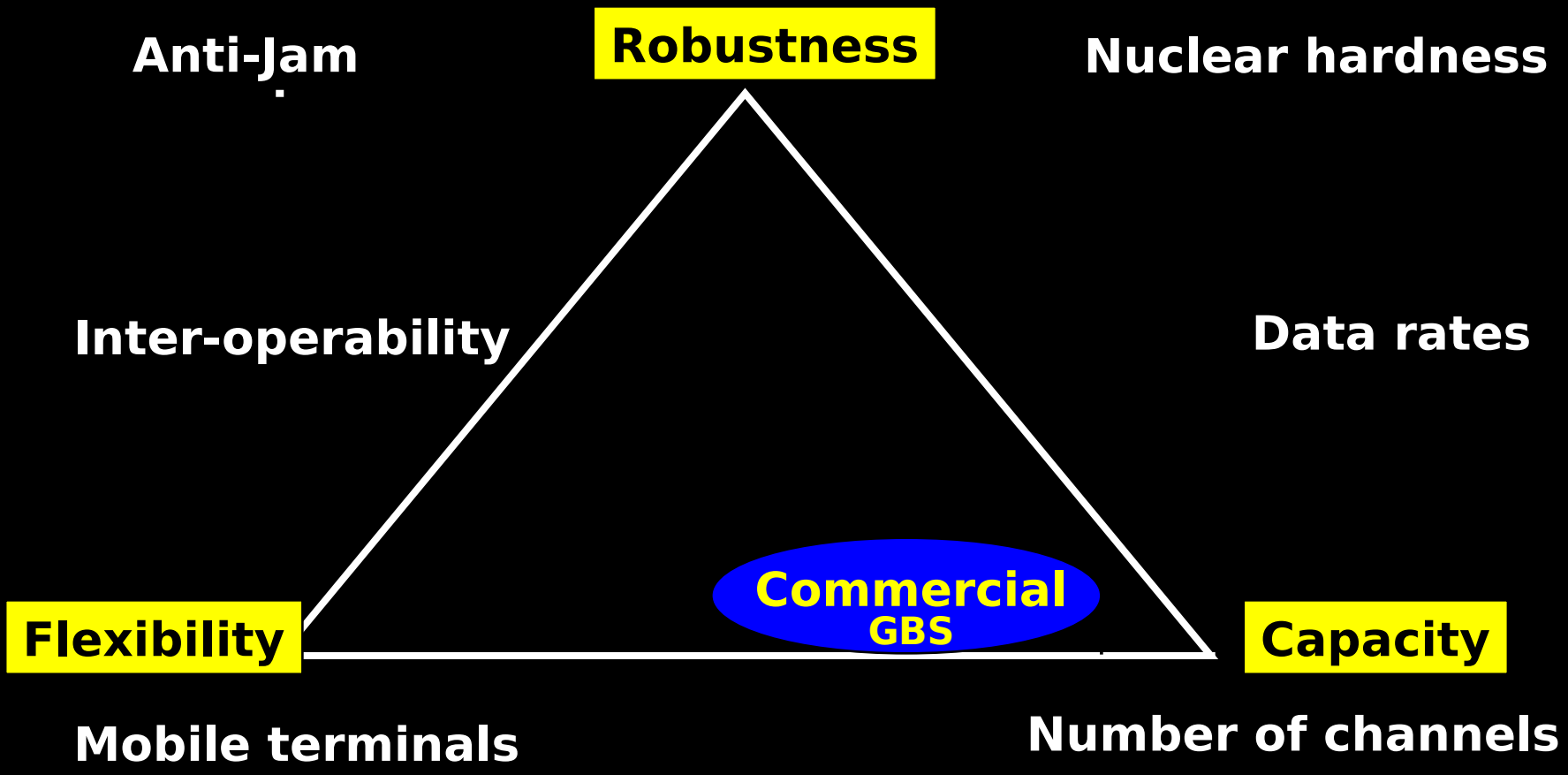
Crossbanding enables connectivity between EHF capable commanders and existing UHF forces

Crosslinking provide inter-theater connectivity without use of vulnerable relay nodes (M-Hops)

Milstar's Antenna Design



EHF GBS MILSATCOM



Why Do We Need GBS?

- **Information Flow to Lower Echelons**
  - **Time critical information, crucial to operations during DESERT STORM had to be airlifted to warfighters, because other communications (mil and commercial) channels were overwhelmed**
    - **Maps**
    - **Imagery**
    - **Intelligence data**
- **GBS was identified as a high priority requirement to sustain information dominance and military superiority following the Gulf War**

Why GBS?

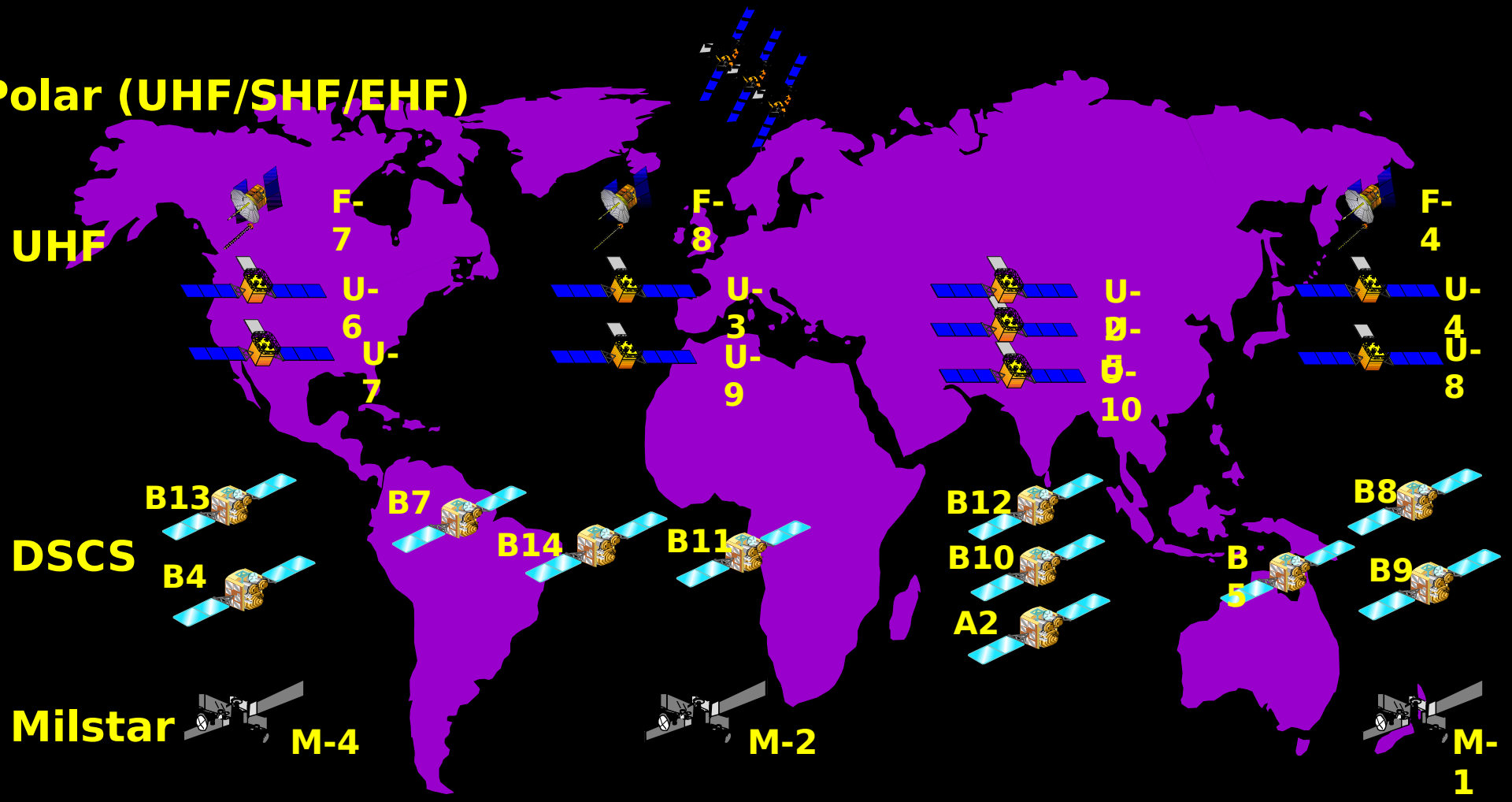
SATCOM	2.4 Kbps MILSTAR	512 Kbps SIPRNET	1.5 Mbps (T1) MILSTAR	2
ATO 1.1 MB	1.02 Hrs	17.09 Sec	5.7 Sec	
Tomahawk MDU 0.03 MB	100 Sec	0.47 Sec	0.16 Sec	
8x10 Imagery 23 MB	22.2 Hrs	6.25 Min	2.07 Min	
DS TPFDD 250 MB	9.65 Days	1.09 Hrs	21.59 Min	

A 24 byte request can get you 24 million bytes of information!

GBS Limitations/Considerations

- **Managing the information**
- **Receive suites much more costly due to military requirements**
  - **Variable data rates (wide area beam, theater inject, variable antenna sizes, mobile platforms)**
  - **Frequency band (Ka on UHF F/O)**
  - **Multimedia/networking (not primarily video)**
  - **DOD approved security**
  - **Mobile platforms**
- **Lack of US control**
  - **Host Nation Agreements (HNA)**
  - **Landing Rights**
- **Not Low Probability of Intercept/Detection (LPI/LPD)**

What We Manage Today



29 DOD Satellites, 700-800 Mbps; $8B+

Note: All But Polar Sats Are In Geosynchronou

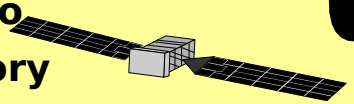
Overview

- Basic Principles
- Military Satellite Communications
- **COMMERCIAL SATELLITE COMMUNICATIONS**
- The Way Ahead

Integrated MILSATCOM Architecture

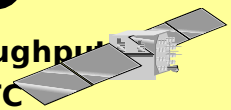
COMMERCIAL

- MDR/HDR Throughput
- Large Files/Video
- On-orbit Inventory
- Surge Capability
- Pay as You Use/Low Initial Investment



SHF (DSCS)

- MDR/HDR Throughput
- Bulk File Xfr/VTC
- Joint/Allied (U.K./Japan) Interop
- JAM Resistant/Infrastructure In Place
- Pt-to-Pt/Hub Spoke

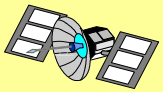


EHF (MILSTAR)

- LDR/MDR Throughput
- MDR Large File Xfr
- Joint Interoperability
- AJ/LPI Protection
- Most Survivable
- Circuit

UHF (UFO)

- LDR Only
- Joint/NATO/AUSCANZUKUS Interoperability
- Low Cost Terminal
- Man Portable/Aircraft/Ships/Sub
- 1/2 Duplex Multipoint/Mesh



Ka (GBS)

- HDR Throughput (24 Mbps)
- Very Large File XFT/WB Video
- Joint Interoperabl

Commercial SATCOM
Operational & Economic Advantages

- **"...additional capacity (tremendous increases in available bandwidth and flexibility, as well as alternative communication paths)...**
- **Continuity of high-bandwidth service in the event of the degradation or loss of government capability...**
- **Relatively short-acquisition time high launch rates allows use of newer technologies**

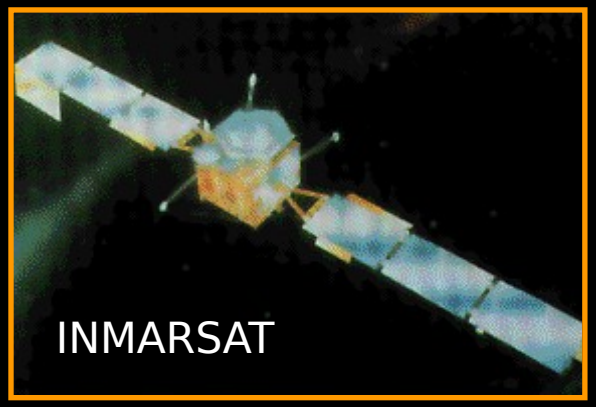
- General Thomas S. Moorman, Jr., USAF Ret.

"The Explosion of Commercial Space and the Implications for National Security"

Commercial SATCOM

Advantages

- **Extensive Capacity**
- **Many Capabilities & Services (Paging, Voice Comm, Data Services, Video +)**
- **IMPACT**
  - **Augmentation to MILSATCOM available**
  - **Tailor to Services Needed**



Disadvantages

- **Interception/Jamming/Geo-location**
- **Limited system control - contract, lease**
- **Availability and coverage**
- **Immediate Cost**
- **Many systems - few standards**
- **IMPACT…must consider suitability of use**

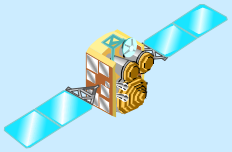
Overview

- Basic Principles
- Military Satellite Communications
- Commercial Satellite Communications
- **THE WAY AHEAD**

Advanced MILSATCOM

APPROVED BY JROC - Oct 97

99 00 01 02 03 04 05 06 07 08



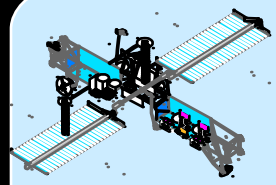
Wideband

- "3" Gapfiller satellites
- SHF/GBS (Ka)/2-Way Ka
- Offload "fixed" users
- Watch commercial market

Risk

DSCS | DSCS-SLEP GBS II | DSCS-SLEP Gapfiller GBS II | Future Wideban (TBD)

B8 B11 B6 A3 ? ? ?



Protected

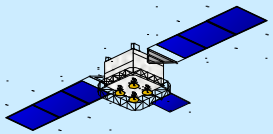
- "4" Advanced EHF satellites "Stay the course"
- Polar - USAF to fully fund 3rd package

Milstar | Risk | Advanced EHF

M3 M4 M5 M6 ? ? ? ?

Polar Hosted

Risk ? ? Risk



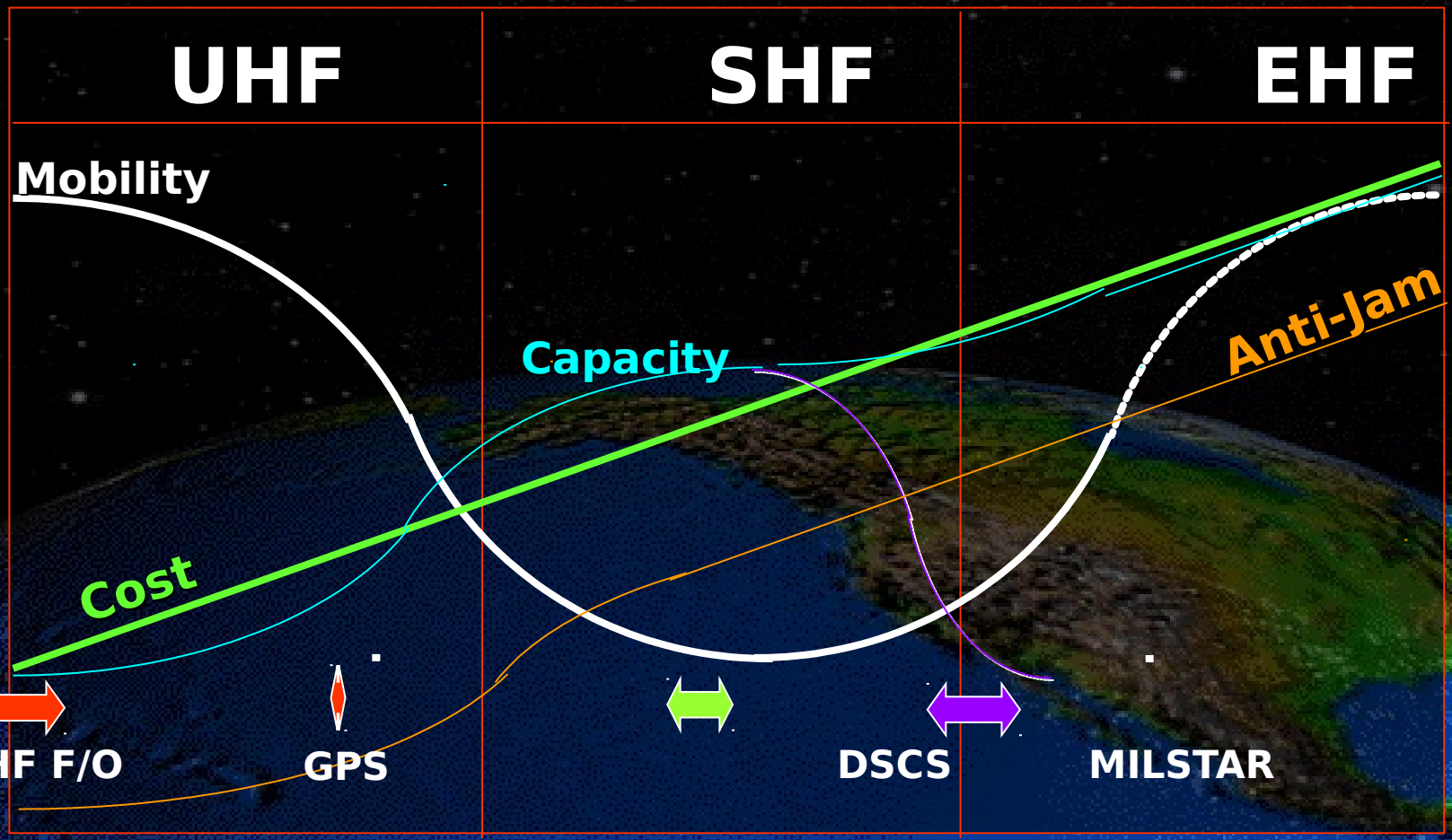
Narrowband

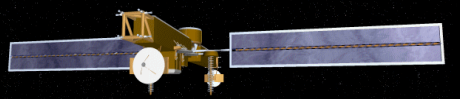
- Understand UHF risks
- Mitigate with hedges
- Assess Commercial
- Look at objective system for '07 and beyond

UHF F/O using DAMA | Advanced UHF

F10 F11 Risk ? ? ?

Summary


UHF
SHF
EHF
Mobility
Capacity
Cost
Anti-Jam
High
Low
UHF F/O
GPS
DSCS
MILSTAR
300 MHz
3 GHz
30 GHz
300
GHz



Satellite Communications (SATCOM)

Business of Space
5 Dec 2001

Space Operations Scho